

LIFE IN THE UNIVERSE EXAM 3 REVIEW SHEET

HABITABLE ZONES AROUND STARS

Standard Criterion – liquid water for 800+ Myr (*continuously* habitable zones - CHZs)

Planetary T set by:

$L_{\text{star}}(\text{time})$ – greater L increases T; L_{star} increases in post-main sequence evolution

Reflectivity – greater reflectivity lowers T

Greenhouse effect – increases T by reducing planet's ability to lose energy in IR

Atmospheric evolution – the composition changes with time due to many factors

Urey reaction – presence of liquid water removes one greenhouse gas – CO_2

Hart Models – CHZ only between F7-K1 ($1.2 - 0.85 M_{\text{sun}}$) – zone typically less than 0.07 AU wide

Boundaries set by runaway greenhouse & runaway glaciation

Some models (i.e. Kasting's) have thicker CHZs

EXTRASOLAR PLANETS

Most young solar-like stars possess dusty disks (silicates, organics)

Detection Strategies – imaging, astrometry, eclipses & gravitational lensing, Doppler effect

As of 2006 - ~150 stars known to have planets – *all detected via Doppler effect*

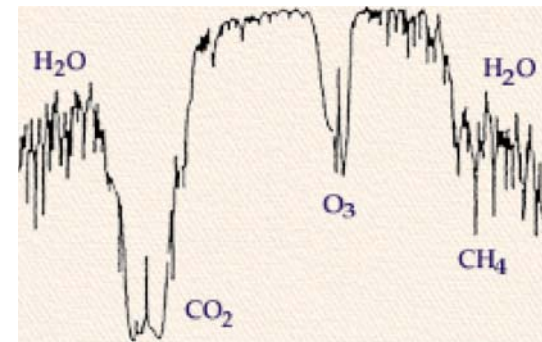
Majority are “hot Jupiters” since Doppler easier to do for massive planets close to star – *selection bias*

Hot Jupiters & planetary migration during disk phase

Two now also detected using eclipses (transits)

6-8 Earth Mass terrestrial(?) planet recently detected

Detecting Life on TPs? – spectroscopy using interferometers – look for *combinations of molecules*



THE DRAKE EQUATION – “RUNNING THE ODDS”

$$N_{ic} = R_{ic} \times L_{ic}$$

where

N_{ic} = # of intelligent civilizations capable (and interested in) communication

R_{ic} = rate (# per year) such civilizations arise

L_{ic} = lifetime (years) such civilizations last

R_{ic} can be broken down into factors that can be estimated with varying degrees of confidence

$$N_{ic} = R_* P_p P_e N_e P_L P_I L_{ic}$$

Don't need to *memorize* this equation in detail, but understand (“feel”) what it *means*

L_{ic} is probably the most unknown factor in the equation

Fewer civilizations = greater average separation

“THE ANSWER” CAN REALLY ONLY BE FOUND BY *LOOKING!*

INTERSTELLAR SPACE TRAVEL

High speed leads to time running slower on spacecraft than on Earth

Final speed depends on speed of exhaust of rocket engine and $(\text{payload} + \text{fuel}) / (\text{payload})$ ratio M

Round trip (acceleration, deceleration, acceleration, deceleration) will depend on M^4

Making the fuel for a “conventional” rocket would be expensive (and the rocket very very slow)

Making the fuel for an unconventional one (i.e. matter-antimatter) is *outrageously* expensive!

Project Orion – thermonuclear explosions propel the craft

Craft not carrying their own fuel: interstellar ramjets, solar sails

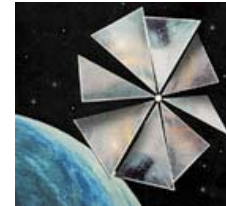
Exploration by proxy robots – von Neumann machines

Interstellar Dust – deadly at high speed!!

Current Interstellar Craft – Pioneer 10 & 11, Voyager 1 & 2- none likely to come close to a star

Pioneer 10 – information plaque

Voyager 1 & 2 – recording of signs & sounds of Earth



SETI

Photons are cheaper than spacecraft

Narrow-band signals easier to detect over noise; broad-band signals can carry more information

Quietest background noise is near 21-cm neutral hydrogen spectral line

Will need to compensate for Doppler shift & get frequency coverage by multichannel detectors

Searches Types – Directed, Dedicated, Shared. May be Targeted or Survey. SETI@home

First search – Project Ozma (1960) by Frank Drake (...the Drake Equation...)

Paul Horowitz pioneers multichannel analyzers: META, BETA (and goes into optical SETI)

NASA SETI – planned Survey & Target Search – killed by Congress

SETI Institute – continued NASA Target Search as Project Phoenix. The Allen Telescope Array

Designing Messages – minimize possible permutations, need “primers” (how to count, etc.)

1974 – Drake transmits message using Arecibo radio telescope

SETI Protocol – there are a number of procedures to be followed before announcing a signal to world

THE FRINGE

“Unidentified” means *unidentified*

Project Blue Book – less than 2% could not be explained (most were aircraft or astronomical objects)

Gulf Breeze sightings – props & confessions cast great doubt – even UFO community concludes: hoax

Alien abductions

Roswell “crash”

US GAO Report – no crashed saucer or aliens



Debris identified by university researchers as theirs – part of classified Project Mogul

Alien Autopsy Film – declared hoax by medical examiners, UFO types. Fox makes \$\$ both ways

Alien Astronauts – claimed by von Dainiken to be responsible for all sorts of ancient things

Crop Circles : visit www.circlemakers.org!



The “Face” on Mars

Eric Julien & SW3; Heaven’s Gate

Teaching Pigs to Sing vs. “I want to believe” (with apologies to “The X-Files”)

OTHER STUFF

Tales of advanced “alien” civilizations go back at least 3000 years

Where are THEY?

Space Travel & Colonization? – Expensive? Slow? Stall? Porous?

Examples from “recent” history – Easter Island (Rapa Nui), Ming Dynasty navy & Zhen He

Dyson Spheres – none detected so far

Relic alien artifacts (*a la* 2001: A Space Odyssey) – none detected so far

We know of no reason why life cannot exist elsewhere

We have detected planets orbiting other stars.

BUT:

We have not found life outside Earth in the solar system

We have not unambiguously detected signals from ETs

There us currently no known evidence for visiting ETs that has withstood *careful* scrutiny

Must keep an open mind but be subservient to the facts – often a fine balancing act!

